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ANIMAL SCIENCE

Physical and chemical characteristics of meat from lambs fed sorghum silage with cashew bagasse

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Abstract: This study was conducted to evaluate the effects of replacing forage sorghum for dehydrated cashew bagasse (DCB) in the proportions of 0; 8; 16 and 24%, based on the natural matter at the time of ensiling on the physicochemical parameters of meat from feedlot lambs. None of the physical parameters evaluated showed a significant difference between the substitution levels of sorghum forage for DCB. The final pH obtained in this study showed a value above the recommended for freshly slaughtered meat from animals 24 hours in refrigeration, being considered DFD meat (dark, firm and dry). Regarding the chemical parameters, it was observed that there were no significant differences between the levels of substitution of sorghum forage for DCB to variable moisture and ash was perceived negative linear effect for protein and quadratic effect on lipid levels meat. The replacement of forage sorghum up to 24% of dehydrated bagasse cashew the ensilage does not compromise the quality of the meat, however, the substitution of 8% is to be preferred because it provides meats with lower lipid content.

Key words: additive, *Anacardium occidentale*, native breeds, meat quality, residue.

INTRODUCTION

The northeast of Brazil concentrates more than 57% of the herd sheep in the country that are created in production systems based on native pasture, whose average annual availability of phytomass not exceeding four tonnes (t) of dry matter (DM) ha^{-1}, of which only 10% are available for animals (Pereira Filho et al. 2013).

The greatest availability of forage in this region occurs during the rainy season, which is concentrated in three to four months of the year, representing about 70% of the annual rainfall (Araújo 2011). With the rain shortage and the advance of the dry season, the chemical composition of the vegetation will be altered, with a decrease in the values of crude and digestible protein and an increase in the levels of fibers and lignin (Campos et al. 2017).

In this scenario, the silage is configured as a primordial alternative and among the most widely used forage plants this process is sorghum (*Sorghum bicolor* (L.) Moench), which stands out in the arid and semi-arid regions by higher resistance to drought than corn, besides the potential of regrowth, which can reach up to 60% achieved in the first cut, and lower production cost (Von Pinho et al. 2007).

Aiming to improve the quality of silage such as high nutritional and hygienic quality of silages, various additives are being studied, including the peduncle of the cashew (*Anacardium occidentale*), whose Northeast production exceeds two million t ano^{-1}, which represents 98% of national production, with underutilization of agro-industrial residues (Barreto et al. 2014). However, changes in diet influence some parameters related to the quality of the meat with more profound effects on its composition, pre and post-slaughter technology and factors related to the consumption (Guerrero et al. 2013).

Thus, it becomes essential to the physical and chemical assessments so that it can determine the effects of feeding on meat quality. In evaluating the physical composition should be measured the cooking loss, texture, color and pH, as juiciness, color and softness are criteria that attract the consumer at the time to make the purchase of meat (Santos et al. 2013). The determination of the chemical composition is necessary to know if the moisture, protein, minerals and lipids in the meat and that will define the nutritional profile of the same.

In the chemical composition of cashew bagasse, according to a survey conducted by Barreto et al. (2014), the average levels obtained were 15.0% of crude protein, 76.5% of total carbohydrates and 5.0% of ether extract, which leads to the hypothesis that the inclusion of the cashew by-product, associated with the forage of sorghum in the silage will improve the quality of the stored forage and, consequently, promote greater performance to the confined lambs.

Thus, the study was conducted to evaluate the effect of substitution of sorghum by dehydrated cashew bagasse in the silage, the physical-chemical parameters of meat feedlot lambs.

MATERIALS AND METHODS

The research was conducted at the Federal Institute of Education, Science and Technology of Rio Grande do Norte (IFRN), in Apodi/RN, and was approved by the Animal Use Ethics Committee (CEUA) of the Federal University of the Semi-Arid Region (UFERSA), under nº. 23091.005940/2013-13. The experimental period lasted six months (September 2013 to March 2014, period from spring to autumn in Brazil), where the average rainfall values, maximum temperature, minimum temperature, average temperature and average relative humidity was 157.3 mm; 35.4ºC; 24ºC; 28.4ºC and 62.8%, respectively (INMET 2014).

The males lambs, not castrated and crossbreed Morada Nova (½) and Santa Inês (½), were observed since its birth (all animals born from single births) and entered into experiment for a period of adjustment, necessary for the adaptation of animals to the diet, when they reached the body weight of 14.00 ± 0.5 kg, allowing the entry of weekly batches of four animals, one for each treatment until the animals were 32 added, or 8 animals for each level of substitution of cashew coproduct. The Lambs stayed in individual pens provided with feeding troughs, drinker and mineral feeders. After 14 days adaptation, lambs were weighed again to obtain the average initial body weight (AIBW) the experiment was 15.1 ± 0.71 kg.

The experimental diet (Table I) consisted of silage made using sorghum plants (Sorghum bicolor), harvested when the beans have reached the farinaceous stage, and cashew bagasse acquired still damp in juice agroindustry, dried in solar dryer and then milled. At the time of silage, sorghum was replaced by dehydrated cashew bagasse (DCB) in the proportions of 0; 8; 16 and 24%, based on the natural matter, with the DCB mixed forage sorghum at the time of ensiling. The silos were used surface type and each had a capacity of 500 kg of silage, with a density of 500 kg per cubic meter. There was no supply of concentrate supplement adopted for any of the replacement levels.

Table I. **Chemical composition of silages containing substitution levels of sorghum forage for dehydrated cashew bagasse (DCB).**

Nutrients ($g.kg^{-1}$ DM)	DCB	DCB replacement levels			
		0%	8%	16%	24%
Dry matter	852.0	430.6	365.8	424.6	435.2
Organic matter	951.3	893.0	912.3	916.9	925.6
Crude protein	123.2	82.0	71.9	85.7	85.3
Mineral matter	48.7	107.0	87.7	83.1	74,4
Insoluble fiber in neutral detergent	670.6	598.7	628.1	606.8	645.3
Insoluble fiber in acid detergent	461.7	408.2	378.9	391.2	391.5
Ether extract	18.6	25.1	39.6	34.3	36.1
Total carbohydrates	809.5	786.0	800.8	797.0	804.1
Non-fiber carbohydrates	138.9	187.3	172.7	190.2	158.9
[a]Insoluble protein neutral detergent	779.2	353.9	380.2	533.5	533.0
[a]Insoluble protein acid detergent	479.8	291.0	225.9	332.3	384.9
Lignin	266.9	78.6	95.6	122.8	121.3
Tannin	1.85	1.72	1.29	1.66	1.66
[b,c]Metabolizable energy	1,23	1,86	1,87	1,77	1,76

DM = Dry matter. [a] $g.kg^{-1}$crude protein (CP). [b] $Mcal.kg^{-1}$DM. [c] Metabolizable energy obtained from the equation Sniffen et al. (1992), considering 1 kg of TDN equal to 4,409 Mcal of digestible energy (DE) and 1 DE Mcal equal to 0.82 Mcal of metabolizable energy. TDN = Total digestible nutrients.

The silage was provided in two meals a day (8 am and 4 pm), with a calculated daily surplus of 10% in relation to the amount of silage provided in order to guarantee maximum voluntary intake.

The slaughter of the animals occurred after reaching 120 days of feedlot, with the lambs presenting an average body weight of 18.79 kg weighed after the solid fasting period of 16 hours. After fasting, at 9 am, the lambs were transported to the abattoir and slaughtered in accordance with current legislation (BRASIL 2000).

After skinning, evisceration and removal of the head and extremities, the initial pH was measured in the *Longissimus* muscle with the aid of a digital potentiometer, and the warm carcasses were taken to the cold chamber, with plastic protection for 24 hours to an average temperature ± 4°C. After this period the final pH was measured and the carcasses were split longitudinally, and the separate loin region, packed in plastic bags and taken to the Laboratory of Instrumental and Sensory Analysis of the UFERSA, were placed (-10°C) until the completion of the physical analysis.

After slaughter, a cross section was made between the 12th and 13th ribs, exposing the *Longissimus* muscle, where the thickness of subcutaneous fat (EGS) was measured in the distal middle third, using a caliper.

The meat color (System CIE L* a* b*) was determined with the aid of a Minolta Colorimeter Chroma Meter CR-300, according to the methodology described in Houben et al. (2000). Determination of the water holding capacity (WHC) was based on the methodology described by Hamm (1986), adapted for a 5 kg weight and is expressed as percentage retention. The weight loss in cooking (WLC) was obtained after removing two portions of *Longissimus lomborum* muscle (3.0 x 5.0 x 1.5 cm), which were weighed, wrapped in aluminum foil, numbered, and then taken cooking pan in the grill type, preheated to 170°C, until the temperature at the geometric center of the meat reached 71°C. Monitoring the internal temperature was carried out with the aid of a digital thermometer (Delta OHM HD9218 model). After cooking, the samples were cooled to ambient temperature and weighed again, with the result by difference in weight between weightings and expressed in percentage.

For the determination of shear force (SF) were used samples of the same WLC, which were cut parallel to the fibers and free of fats and nerves, to obtain a hexahedron with about 1.3 cm height and wide, yielding four replicates per experimental unit. Samples were analyzed in texturometer TA-XT2, Stable Micro System Surrey coupled to the blade Warner-Bratzler measuring the maximum force, expressed in kgf/cm^2.

The determination of moisture (g kg^{-1}), ash (g kg^{-1}) and protein (g kg^{-1}) followed the methodology described by Adolfo Lutz Institute (Instituto Adolfo Lutz 2008) and the lipid content followed the methodology described by Folch & Stanley (1957), in duplicate, it is held at the Animal Nutrition Laboratory of IFRN, Apodi campus.

The design adopted was completely randomized; data were submitted to analysis of variance (ANOVA) and the effect of the replacement levels assessed by regression analysis at 5% significance, according to the following model: $Yij = \mu + Ai + \varepsilon ij$, where: Yij = value observed at level i; j = replica (animal); μ = general average; Ai = effect of level i; i = replacement levels of dehydrated cashew bagasse; εij = effect of random error attributed to repetition

RESULTS

Neither of physical parameters evaluated was influenced by the levels of replacement of DCB (P>0.05) (Table II). The final pH obtained in this study showed a value (6.59) above the recommended for freshly slaughtered meat from animals 24 hours in refrigeration, a result that should be between 5.5 and 5.7 (Albarracín & Sánchez 2013).

The values of the parameters related to color showed an average of 35.33; 10.32 and 11.32 for the lightness (L*), red intensity (a*) and intensity of yellow (b*), respectively. The weight loss in cooking (WLC) showed average of 40.40% and the average WHC in the present study was 65.02%. Analyzing the SF, there was an average value of 2.62 kgf/cm^2.

Regarding the chemical composition of meat (Table III), it is observed that there were no significant differences (P>0.05) for the variables moisture (756.9 g.kg^{-1}) and ash (11.4 g.kg^{-1}). The lipid content (Table II) presented quadratic behavior (P<0.05), observing slight depression in the intermediate replacement levels (8 and 16%).

DISCUSSION

Regarding the physical parameters, sheep meat with final pH above 6.2 are considered DFD (dark, firm and dry), occurring mainly by the depletion of muscle glycogen levels before slaughter and is associated with stress on pre-slaughter management (Leme 2013). In this case, are attributed as likely stressors slaughter immediately after transport and the climate, because the slaughtering occurred

Table II. **Physical characteristics of the meat fed lambs with silages containing substitution levels of sorghum forage for dehydrated cashew bagasse (DCB).**

Parameters	DCB replacement levels				SEM	P-value	
	0%	8%	16%	24%		Linear	Quadratic
$pH_{(0h)}$	7.21	7.30	7.19	7.16	0,21	0,795	0,785
$pH_{(24h)}$	6.53	6.59	6.58	6.66	0.14	0.533	0.928
L*	35.46	34.89	35.40	35.53	0.82	0.848	0.675
a*	10.97	10.39	10.00	10.02	0.51	0.165	0.557
b*	11.62	11.17	11.24	11.28	0,46	0.646	0.598
[a]WLC	40.09	33.21	42.04	35.22	1.65	0.446	0.985
[a]WHC	62.65	66.89	64.90	65.55	1.61	0.354	0.279
[b]SF	2.56	2.72	2.40	2.50	0.20	0.594	0.897

SEM= Standard Error of the Mean. $pH_{(0h)}$ = pH at the time of slaughter. $pH_{(24h)}$ = pH 24 hours after slaughter and cooling. L* = brightness. a* = red intensity. b* = yellow intensity. WLC = Weight loss in cooking. WHC = water holding capacity. SF = shear force. [a](%) [b](Kgf/cm^2).

in the summer period, when average daily temperatures were around 28.2°C (INMET 2014). According to Leme (2013), for transport of less than two hours should be allowed a rest period of at least six hours.

What should also have contributed to the final pH high was low deposition of subcutaneous fat (1.05±0.41 mm) and lipids in the meat (Table III), which should have promoted rapid cooling and may have compromised the transformations chemical glycogen to lactic acid. This effect is consistent with that reported by Hargreaves et al. (2004), therefore they observed that, as they decrease the carcass fat content, increases the occurrence of DFD meat cattle. The authors attributed this behavior to the fact that fat provide insulation and slow the cooling of the meat.

About the color parameters, studying the inclusion of pineapple, banana, mango and passion fruit, replacing sorghum silage in the diet of sheep, Almeida et al. (2015) found average scores of 40.67; 16.63 and 8.68 for L*, a* and b*, respectively, and Rodrigues et al. (2008), investigating the substitution of corn by citrus pulp in sheep feeding, observed values for L*, a* and b* of 42.62; 14.68 and 7.22, respectively. It is observed that the brightness and intensity of red meat presenting with lower values than the reported studies and this behavior may have been a reflection of the pH final high, which increases the activity of citicromo oxidase, reducing the oxygen uptake (Osório et al. 2009). In addition, the muscle fibers are stretched among meat, which hinders the diffusion of oxygen and light absorption (Cruz et al. 2016), factors that decrease the brightness of the meat and give red purple color by the predominance myoglobin as metmyoglobin. The intensity of the red may also have been influenced by age at slaughter (216±18 days), because Pinheiro et al. (2010) reported that younger animals are meat and less intense red, or the weight of the carcasses (19.24±1.87 kg), once Bressan et al. (2001) observed that smaller weights at slaughter results in lower values of a*.

The intensity of the yellow of the meat showed values higher than those observed in other studies and this response may be related to the presence of carotenoids in the diet for the exclusive use of sorghum silage and DCB. Using silage five sorghum genotypes, Góis (2014)

Table III. Chemical characteristics of the meat fed lambs with silages containing substitution levels of sorghum forage for dehydrated cashew bagasse (DCB).

Parameters	DCB replacement levels				SEM	P-value	
($g.kg^{-1}$)	0%	8%	16%	24%		Linear	Quadratic
Moisture	757.0	760.1	753.2	757.9	0.50	0.851	0.881
Protein	279.9	278.6	266.6	266.1	0.49	0.024[a]	0.938
Lipids	25.5	19.6	21.5	27.8	0.29	0.494	0.045[b]
Ash	11.5	11.3	11.4	11.3	0.17	0.593	0.696

SEM = Standard Error of the Mean. [a]$y = 280.8 - 0.07x$ ($R^2 = 0.85$). [b]$y = 25.3 - 0.10x + 0.004x^2$ ($R^2 = 0.99$).

obtained higher mean values for b* (15.98) and Vieira et al. (2010) observed a trend in increasing the yellow content, as increased cottonseed presence in diet, attributed it to the presence of carotenoids.

The WLC observed was similar to that reported by Almeida et al. (2015), using various fruit residues in sheep feeding (40.18%), and observed by Costa et al. (2011b), who found values of 38.2; 39.8 and 40.9% for non-defined breed lambs (NDL), NBL vs Santa Inês and Santa Inês, respectively. The WLC observed in this study is considered high and can be related to slaughter age, because younger animals have more amount of water in muscle, as observed by Pinheiro et al. (2009) found that most WLC in meat of lambs (46.44%) compared to females and adult males (38.82%), but may also have been influenced by high water holding capacity (Monte et al. 2012).

The average WHC was higher than those found by Rodrigues et al. (2008), Fernandes et al. (2011) and Almeida et al. (2015), which also found no differences (P>0.05) between diets containing citrus pulp (60.1%), fruit residues (61.08%) and grain soy or protected fat (60.6%) in the diet of sheep, respectively. This behavior may have been a reflection of the high final pH, which promotes increased WHC, whose benefit is less loss of nutrients in its cooling and higher juiciness, losing relatively less water in cooking (Zeola et al. 2007).

The mean value presented in this study for SF qualifies the meats with a medium tenderness (2.28 to 3.63 kgf / cm^2) according to the classification of Cezar & Sousa (2007), however, the pH indicates a DFD meat and would be a meat classified as hard or extremely hard. Campêlo et al. (2015), evaluating the quality of sheep meat, DFD meat (pH = 6.07) that dissipated SF of 5.51 kgf / cm^2, presenting a characteristic that was not observed in the present study. What could justify this result would be the slaughter age of the animals, since they were slaughtered at approximately 180 days of age and at that age there is a tendency for softer meats.

Fernandes et al. (2011) slaughtered lambs with ages similar to that of this study and obtained a value of 2.18 kgf / cm^2, in contrast, Almeida et al. (2015), in their research, slaughtered animals with 11 months of age and obtained SF of 4.58 kgf / cm^2, indicating that age can be a fundamental factor for these characteristics. One of the factors that influence the increase in SF with age is related to the increase in the number of collagen thermostable cross-links (Cruz et al. 2016)

The protein content were influenced by the substitution sorghum DCB (P<0.05), reducing as increased residue levels. The negative effect may be attributed to increase in content insoluble protein acid detergent and lignin (Table I), therefore increasing the DCB. The increase in these levels decreases the amount of digestible protein and, consequently, the supply of amino acids for protein synthesis, being reported by Cruz et al. (2016) that the decrease in protein intake in the sheep diet reduces protein deposition in the muscle. The protein levels of meat, although decrease, showed superior to those reported by Costa et al. (2011a), that when assessing the replacement of corn by sorghum obtained value of 184.8 $g.kg^{-1}$ and by Menezes Júnior et al. (2014), who observed average of 225.0 $g.kg^{-1}$ to study three sheep genotypes, and Góis (2014), which investigating five sorghum cultivars in sheep feeding obtained average 240.8 $g.kg^{-1}$.

The cause for this high level may be associated with low protein content in the diet (Table I), because Monte et al. (2012) mentions that diets with lower protein contents lead to higher meat with protein content, the fat content depletion. Another factor that may be associated is the body weight at slaughter (19.25 ± 1.87 kg), once Gonzaga Neto et al. (2005) found that there is a higher protein deposition in the carcass when animals have lower slaughter weight.

Lipid levels observed are below measured by Costa et al. (2011a) investigated the use of melon by sheep, which received an average of 37.6 gkg^{-1}. The low lipid content in the obtained meat of the referent study animals may be due to the absence of the concentrate supplemented resulting in low energy density diets (Table I), which in turn reflected in less accumulation of fat, as stated Bonacina et al. (2011). These levels may have been influenced by the age of slaughter, because they were younger and low weight at slaughter, with meat with low fat (Monte et al. 2012).

The substitution of the sorghum fodder for up to 24% of the dehydrated cashew bagasse, at the time of ensiling, can be used by producers who can associate it with a concentrate source to improve the deposition of fat in the meat.

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